Table 8. Calculated and Measured Dye Concentrations and Dilutions for Each of the Four Cruise Ships.

	Parameter	Vessel			
		Majesty	***Explorer***	***Paradise***	***Fascination***
Calculated Values	Dye - v (L)/ wt.(kg)	114/22.6	133/26.4	133/26.4	137/27.1
	Volume of water + dye in tank (L)	113,114	18,300	108,133	27,137
	Tank Concentration (g/L)	0.1998	1.443	0.244	0.999
	Dye discharged (kg)	21,201	24,669	16,635	24103
	Calculated Plume Volume (L)	36,302,904,000	15,517,320,000	45,503,640,000	6,172,100,000
	Calculated plume concentration (g/L)	5.84E-07	1.59E-06	3.66E-07	3.91E-06
	Calculated Dilution	**342,123:1**	**907,547:1**	**666,667:1**	**255,499:1**
Measured Values	Measured Tank Concentration (g/L)	0.13,512	1.002	0.2704	0.9806
	Measured Plume Concentration (g/L)	3.50E-07	5.13E-06	4.20E-07	3.40E-06
	Measured Dilution	**386057:1**	**195,322:1**	**643,810:1**	**288,412:1**

4. Findings and Conclusions

The August 2001 plume tracking survey was designed to provide field data on the cruise ship discharge (effluent) plume characteristics in offshore waters, and provide information on whether or not the cruise ship blackwater or graywater discharge-plumes behave as predicted by a model developed for Alaska waters (Colonell *et al*. 2000)[2].

Based on the Alaska model, effluent discharges from cruise ships were expected to undergo an initial dilution of approximately 40,000:1. Colonell *et al*. (2000)[2] defines initial dilution as the physical mixing of a relatively small and moving discharge entering the water body and secondary dilutions as caused by mixing by the ship propellers. In this plume and tracking report, initial and secondary are not distinguished, but are called initial dilution.

The following findings for each ship were:

M/S Majesty

Calculated dilution: 342,000:1
Measured dilution: 386,000:1

M/S Explorer

Calculated dilution: 908,000:1
Measured dilution: 195,000:1

[2] Colonell, JM, SV Smith, and RB Spies. 2000. Cruise Ship Wastewater Discharge into Alaskan Coastal Waters. Alaska SeaLife Center Technical Report Number 2000-01. 48pp.

M/S Paradise

Calculated dilution: 667,000:1
Measured dilution: 643,000:1

M/S Fascination

Calculated dilution: 255,000:1
Measured dilution: 288,000:1

This survey indicates that discharges from cruise ships undergo a dilution that is much greater than the initial dilution predicted by a model developed by Collonel et al (2000)[2]. Measured dilutions ranged from 195,000 : 1 to 666,000 :1. This indicates that secondary dilution, as the effluent passes through the propellers is an important factor when considering the ambient concentrations of discharge effluents. The effluent will undergo a dramatic and rapid dilution after mixing with ambient water in the prop wash.

In this study, the observed dilution is unlikely to have been influenced by shear currents. The use of surface drogues allowed the OSV Anderson to maintain position with the dye plume as it moved northward in the Florida current. The drogues maintained a relative position during their drift, which indicates that the plume was not exposed to highly variable currents. The acoustic Doppler current profiler data, obtained from the *Majesty*, also indicates that the plumes did not encounter shear or variability in the current.

5. References

Battelle. 2001. Work/Quality Assurance Project Plan for Cruise Ship Sampling. Prepared for U.S. Environmental Protection Agency Oceans and Coastal Protection Division, Washington, DC. Contract NO. 68-C-00-121, Work Assignment 1-23.

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Colonell, JM, SV Smith, and RB Spies. 2000. Cruise Ship Wastewater Discharge into Alaskan Coastal Waters. Alaska SeaLife Center Technical Report Number 2000-01. 4